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Epilithic algae in the North Channel, Lake Huron

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Introduction

The Upper Great Lakes (Lakes Superior, Huron, and Michigan) are large deep lakes where phytoplankton are the dominant primary producers (VERDUIN 1972). However, in several shallow, protected regions of these lakes, benthic algae and macrophytes may be important primary producers. One such region is the North Channel of Lake Huron, located in the northeast part of the lake (Fig. 1). The North Channel of Lake Huron lies on Precambian rock of the Canadian Shield, and thousands of small rocky islands occur in its waters that encompassing a large number of environments (e.g. shallow, sheltered, etc.) where epilithic algae may be important primary producers.

The purpose of this paper is to examine the abundance, productivity, and composition of epilithic algae in protected regions of the North Channel of Lake Huron. We sampled protected coves/bays where recreational boating activities were high to provide a benchmark for future studies determining the impact of recreational activities.

Key words: periphyton, Great Lakes, benthic, primary productivity, photosynthesis

Materials and methods

During the summers (July/August) of 2001, 2002, and 2003 four shallow (depth < 3 m) coves (bays) were sampled in the eastern part of the North Channel of Lake Huron. The four coves were: Cleary Cove on Dewdney Island (46°08.07′N; 82°37.48′W); Pool at Baie Finn (46°02.66′N; 81°28.71′W); Covered

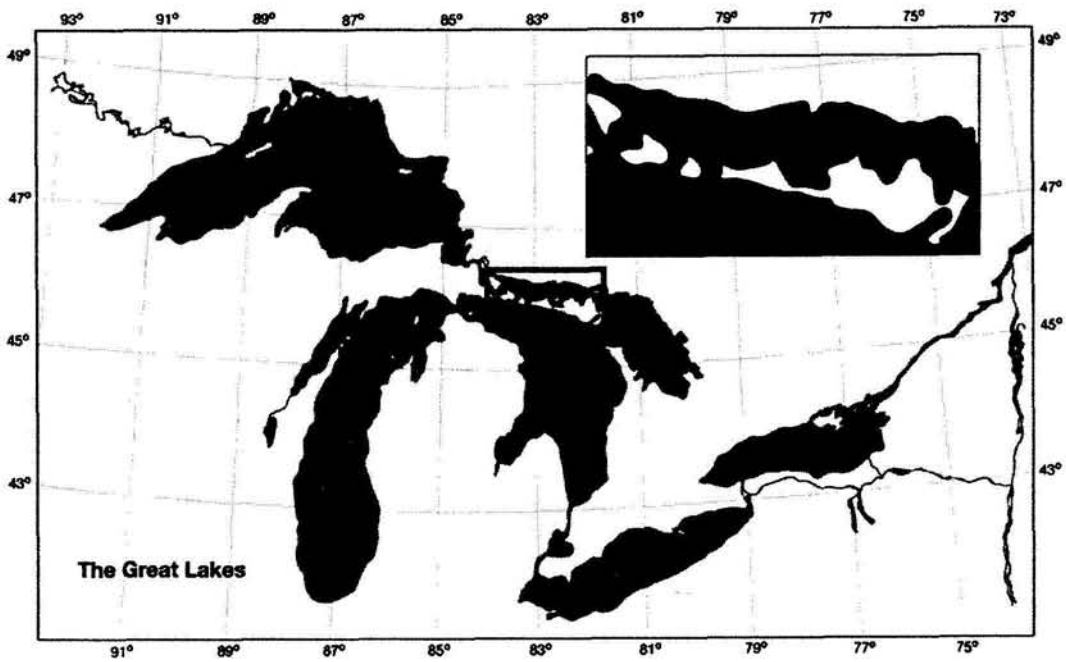

Fig. 1. Map of North Channel, Lake Huron.

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Portage Cove (45°59.94'N; 81°32.74'W); and South Benjamin Islands (46°05.05'N; 82°14.85'W). At each of these locations, at least two stations were sampled, and at least four rocks were sampled at each station.

All rocks were carefully removed from the environment so as not to disturb the epilithic algae. The algae were gently scraped off the rocks using a small rubber spatula and brush while constantly rinsing the rock with filtered lakewater. Subsamples of each algal slurry were then either preserved with Lugol's solution or filtered onto GF/F filters for chlorophyll analysis. Chlorophyll filters were extracted with DMF and analyzed fluorometrically (FAHNENSTIEL et al. 2000). Lugol's preserved samples were filtered onto membrane filters, cleared, and analyzed for algal composition (FAHNENSTIEL et al. 1998).

Underwater light extinction of photosynthetically active irradiation (K_{PAR}) was measured with a LICOR-193 SB scalar light sensor and LICOR-1000 data logger. Surface incident irradiation was measured using a LICOR sensor and data logger.

In situ primary productivity was estimated by gently sliding rocks into polycarbonate bottles then placing them near the original location of the rocks. Carbon-14 was then added to each bottle, and the bottles incubated for 2–4 hours during the middle of the day. At the end of this period, the rocks were removed from the bottles, algae scraped into containers and aliquots filtered onto membrane filters. These filters were decontaminated then counted by liquid scintillation counting (FAHNENSTIEL et al. 2000). Total CO_2 and total C-14 activity were determined from water samples of each bottle. Hourly *in situ* production values were converted to daily production by normalizing production to *in situ* irradiance (hourly values) and then summing for the day.

Photosynthesis-irradiance relationships (P-E) were determined for two coves, Covered Portage Cove and the Pool at Baie Finn. For these experiments, rocks were collected and algae scraped into polycarbonate containers. Carbon-14 was added to this algae slurry, and then 3-ml samples were dispensed into scintillation vials. After a short incubation in a photosynthetron (30–40 minutes), the contents from each scintillation vial were filtered onto membrane filters (FAHNENSTIEL et al. 2000). The activity on filters was counted with liquid scintillation counter. P-E parameters (maximum light saturated rate – P_{max} and initial linear slope, α) were determined as described in FAHNENSTIEL et al. (2000). Similarly, P-E measurements were made on phytoplankton samples (whole water) at two stations. Phytoplankton P-E parameters were combined with phytoplankton chlorophyll concentrations, incident irradiance measurements and K_{PAR} values to determine phytoplankton integral primary production using the Great Lakes Production Model (LANG & FAHNENSTIEL 1995).

Results and Discussion

Chlorophyll concentrations for epilithic algae ranged from 0.2–4.2 mg m^{-2} with a mean of 1.7 mg m^{-2} (Table 1). The lowest chlorophyll concentrations, 0.2–0.3 mg m^{-2}, were found at the most oligotrophic site (South Benjamin Island) where K_{PAR} values were 0.18 m^{-1}. At the other three sites, chlorophyll concentrations ranged from 1.1–4.2 mg m^{-2}, and K_{PAR} values ranged from 0.3–0.35 m^{-1}. These chlorophyll values are similar to values reported for epilithic algal communities from other oligo-

Table 1. Chlorophyll concentrations (mg m^{-2}), *in situ* primary production (mg C m^{-2} h^{-1}), assimilation number (mg C mg Chl h^{-1}), and diatom biovolume (%) for epilithic algal communities at sites in the North Channel, Lake Huron.

Site and station	Chlorophyll	*In situ* Production	Assimilation number	Percent Diatom Biovolume
Dewdney Island-1	2.2 ± 0.1	1.1 ± 0.2	0.5	43
Dewdney Island-2	1.3 ± 0.1	0.9 ± 0.1	0.7	58
Baie Finn-1	1.1 ± 0.1	0.8 ± 0.2	0.7	86
Baie Finn-2	2.4 ± 0.06	2.4 ± 0.2	1.0	81
Baie Finn-3	4.2 ± 0.2	3.8 ± 0.2	0.9	80
Covered Portage-1	1.3 ± 0.1	1.8 ± 0.2	1.4	77
Covered Portage-2	2.7 ± 0.3	2.7 ● 0.3	1.0	70
South Benjamin-1	0.2 ± 0.01	0.2 ± 0.01	1.0	98
SouthBenjamin-2	0.3 ± 0.01	0.2 ± 0.02	0.7	74

Table 2. Photosynthetic parameters (P_{max}, mg C mg Chl h^{-1} and α, mg C mg Chl^{-1} mol $quanta^{-1}$ m^2) and integrated primary production (mg C m^{-2} d^{-1}) for epilithic algae and phytoplankton (phyto.) communities at two sites in the North Channel.

Site	Epilithic Algae P_{max}	Epilithic Algae α	Epilithic Algae Int. Pri. Prod.	Phyto. P_{max}	Phyto. α	Phyto. Int. Pri. Prod.
Covered Portage-1	1.7	5.5	20	3.5	4.7	240
Baie Finn-3	1.8	7.7	46	4.0	5.0	310

trophic/mesotropic lakes (JONSSON 1987, KING et al. 2002).

At all sites, except for Dewdney Island, diatoms dominated the epilithic algal assemblage. Diatom biovolume ranged from 43–98% of total algal biovolume with a mean of 74% (Table 1). With the exception of the Dewdney Island sites, chlorophyte biolovolume was 1–23% of total algal biovolume, and cyanobacteria biovolume was only 0.1–9%. Dominant diatoms included *Achnanthes minutissima* [Kütz]., *Cymbella gracilis* [Kütz.], *Fragilaria construens* Grunow, *Denticula tenuis* [Kütz]., and *Cocconeis placentula* Ehrneberg. At Dewdney Island, the chlorophytes and cyanobacteria were more abundant, representing 35% and 15% of total algal biovolume, respectively. The dominant chlorophyte was *Oedogonium* sp., and the dominant cyanobacteria was *Calothrix*. The dominance of pennate diatoms at most sites is consistent with the findings for other epilithic communities in oligotrophic, soft-water lakes (KING et al. 2002).

In situ primary productivity rates ranged from 0.2–3.8 mg C m^{-2} h^{-1}, with lowest rates at the most oligotrophic station (Table 1). Our *in situ* rates are within the range of *in situ* productivity rates reported for epilithic algae in oligotrophic lakes Tahoe and Thingvallatin (LOEB 1981, JONSSON 1992). Epilithic biomass was the dominant factor explaining the variance of *in situ* productivity, as chlorophyll concentrations were strongly correlated with production (Table 1, $r = 0.94$, $p < 0.001$). Assimilation numbers, or production/biomass ratios, varied from 0.5–1.4 mg C mg Chl h^{-1}, which are very similar to those reported for epilithic communities in Lake Thingvallatin (JONSSON 1992).

Photosynthetic-irradiance parameters for epilithic algae appeared to be different than those for phytoplankton from the same environment (Table 2). P_{max} values were lower for epilithic algae, but α values were somewhat higher. These differences may be related to light adaptation and the lower *in situ* light levels found for epilithic algae.

Not only is this the first study to report *in situ* productivity and P-E parameters for diatom-dominated, epilithic algae in the Laurentian Great Lakes, but we were able to evaluate the contribution of epilithic algae to system primary productivity. At the two sites examined, epilithic algal contributed 8–15% of phytoplankton productivity (Table 2). While this represents a small fraction of total system primary productivity, the contribution to overall food-web productivity may be greater due to the concentrated abundance of certain benthic invertebrates on the rock substrates. The food-web contribution of these epilithic algae merits further study in this region of the Laurentian Great Lakes.

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